TECHNICAL MEMORANDUM NO. 22

# THE PERFORMANCE OF A BANK OF DOUBLE, ISOLATED, SYNCHRONOUSLY - TUNED FILTERS FOR RECOVERING TONE BURST TELEMETRY SIGNALS

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Technical Memorandum No. 22

To: Cyrus J. Creveling
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Anacostia Naval Station
Washington 25, D. C.

Re: Contract No. NAS 5-408

Subject: The performance for recovery of tone-burst telemetry signals of a bank of filters each one of which is composed of two isolated, cascaded, synchronously-tuned circuits.

## Summary

In Memorandum No. 21 the performance of a bank of single-tuned filters for recovery of tone-burst telemetry signals was evaluated. The performance of a bank of filters each one of which is composed of two identical, isolated single-tuned circuits in cascade, has now been evaluated and compared with that of a bank of single-tuned filters. For brevity this filter will be referred to as a double-tuned filter. The performance of the double-tuned filter has been found to differ only slightly from that of the single-tuned filter. With respect to signal-to-noise ratio the double-tuned filter is an average of approximately 0.5 db superior to the single-tuned filter and with respect to resolution signal-to-noise ratio it is an average of approximately 0.85 db inferior to the single-tuned filter.

## Discussion

In Memorandum No. 19 the envelope response to a tone-burst, of a double-tuned filter was shown to be

$$E_u(t) = \frac{1}{1+4x^2}\left\{1+[(1+\pi Bt)^2+(2\pi Bxt)^2]e^{-2\pi Bt} - 2[(1+\pi Bt)\cos 2\pi Bxt + 2\pi Bxt \sin 2\pi Bxt]e^{-\pi Bt}\right\}^{1/2}$$

where

$E_u(t)$ = normalized envelope magnitude

$x = \Delta f/B$

$\Delta f$ = offset frequency (cps from center of pass-band).

$t$ = time

$B$ = 3 db bandwidth of one stage of filter.

In Figure 1 the output signal-to-noise ratio vs. the 3 db bandwidth of one stage of the double-tuned filter is plotted for several offset frequencies. The sampling time has been chosen to be ten milliseconds corresponding to the end of the input tone burst since, as for the single-tuned filter, the maximum output occurs at this time for most of the significant range of offset frequencies. The overall 3 db bandwidth of the filter is related to the 3 db bandwidth of a single stage by

$$\text{overall 3 db bandwidth} = \sqrt{2^{1/2} - 1} \times (\text{3 db bandwidth of one stage})$$

$$= .644 \times (\text{3 db bandwidth of one stage})$$

It should also be noted that since in Memorandum No. 21 the output signal-to-noise ratio was plotted as

$$E_u/\sqrt{3} \text{ db bandwidth}$$

$$= \sqrt{\frac{\pi}{2}}\ E_u/\sqrt{\text{noise bandwidth}}$$

The output signal-to-noise ratio for the double-tuned filter has also been plotted as

$$\sqrt{\frac{\pi}{2}}\ E_u/\sqrt{\text{overall noise bandwidth}}$$

so that the plots for both the single-tuned and double-tuned filters may be compared directly.

In Figure 2 the resolution signal-to-noise ratio vs. the 3 db bandwidth of one stage of the double-tuned filter is plotted for several offset frequencies.

The general characteristics of these curves for output signal-to-noise ratio and resolution signal-to-noise ratio are the same as those for the single-tuned filter. The curves have peaks which become flatter and occur at wider bandwidths as the offset frequency increases. As shown in the table below the double-tuned filter has a slightly superior performance with respect to output signal-to-noise ratio and a slightly inferior performance with respect to resolution signal-to-noise ratio, when compared to a single-tuned filter.

| Peak Output Signal-to-Noise Ratio | |
|---|---|
| Offset frequency - cps | Peak snr, double-tuned/Peak snr, single tuned -(db) |
| 0 | 0.23 |
| 25 | 0.40 |
| 35 | 0.56 |
| 45 | 0.78 |

| Peak Resolution Signal-to-Noise Ratio | |
|---|---|
| Offset frequency - cps | Peak resolution snr, double tuned/Peak resolution snr, single tuned(db) |
| 0 | -0.16 |
| 10 | -0.68 |
| 25 | -1.08 |
| 35 | -1.16 |
| 45 | -1.17 |

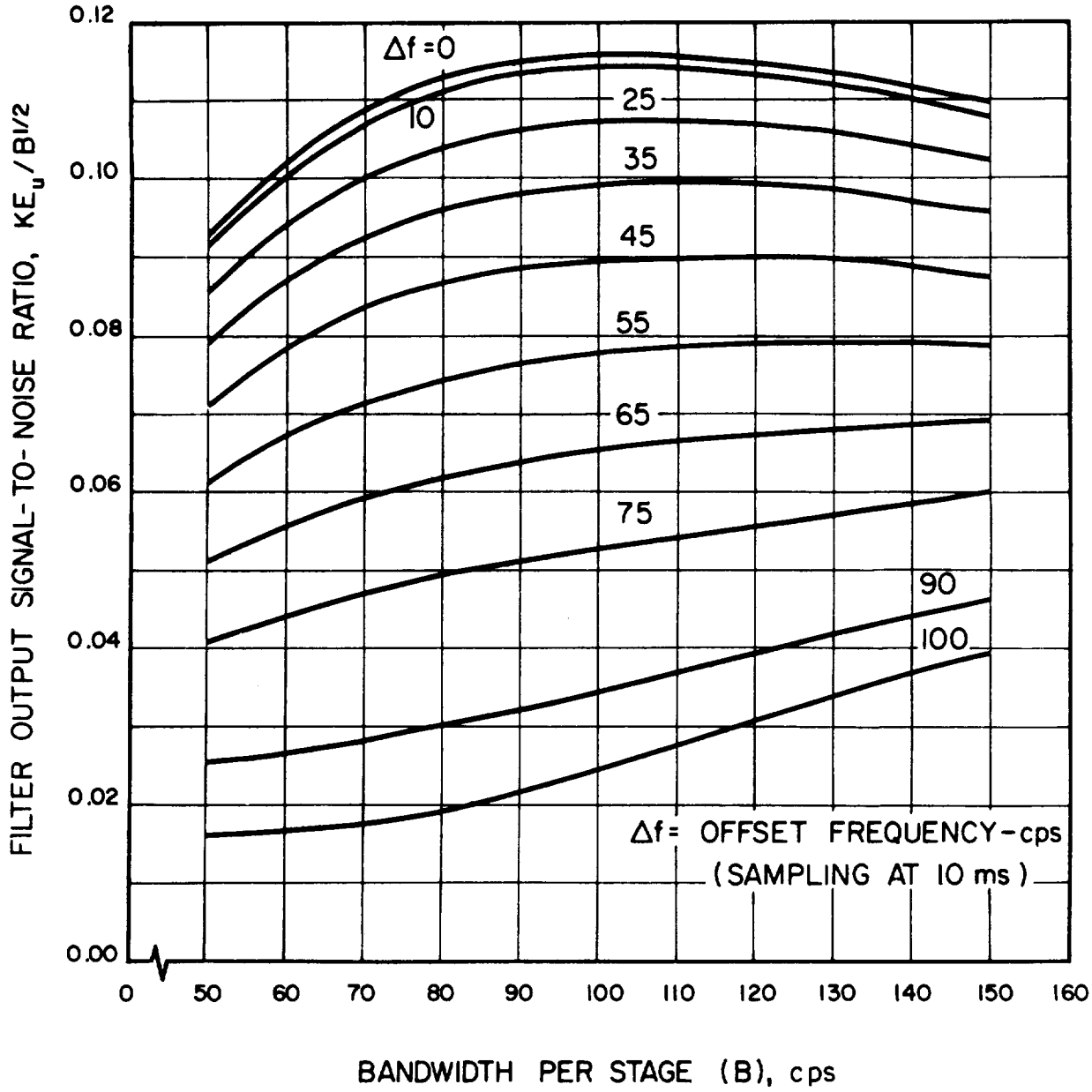


Fig. 1 Output signal-to-noise ratio vs. 3-db bandwidth of a single stage for a filter consisting of two isolated, cascaded, synchronously tuned circuits, for several offset frequencies.

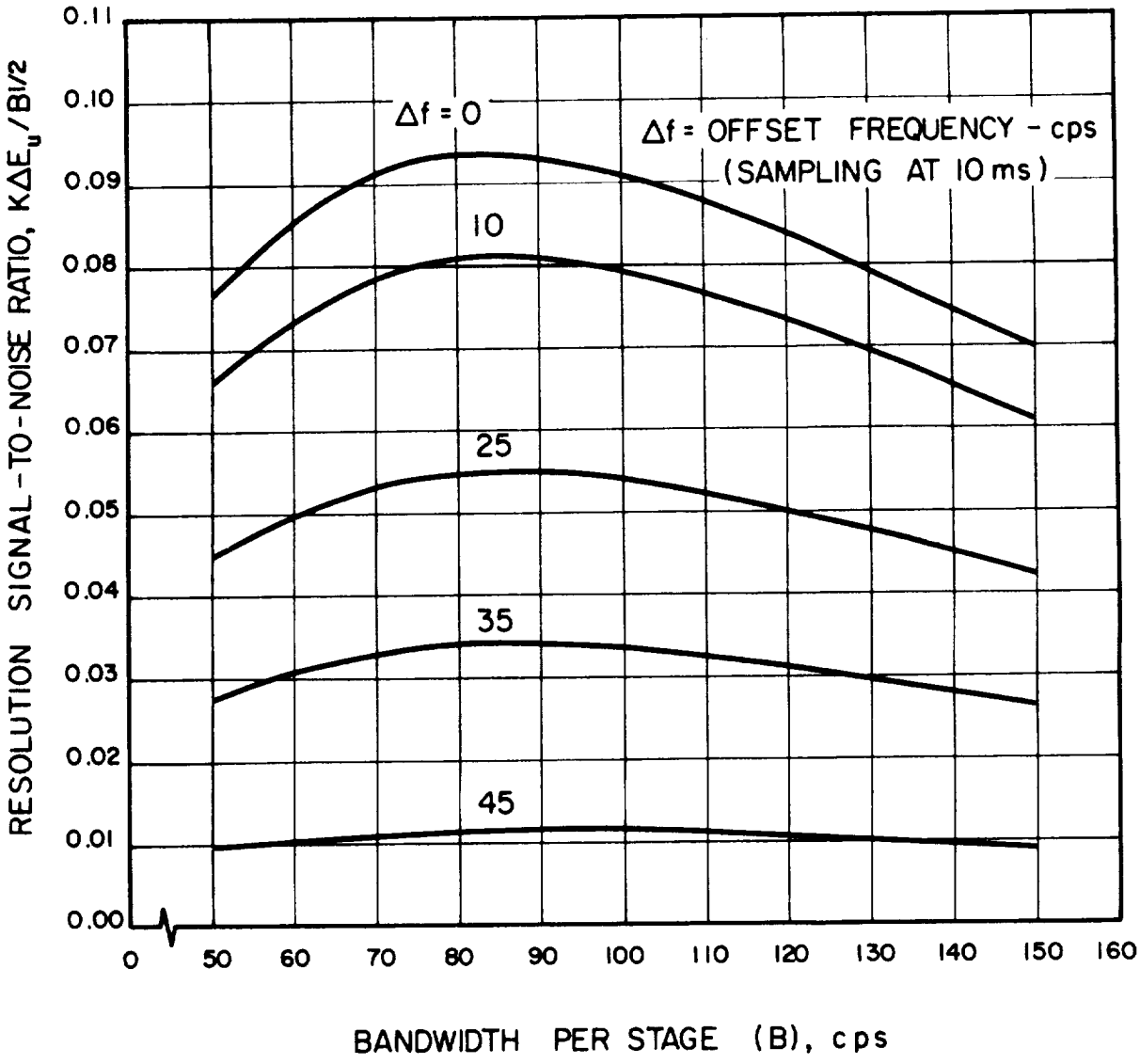


Fig. 2 Resolution signal-to-noise ratio vs. 3-db bandwidth of a single stage for a filter bank in which each filter consists of two isolated, cascaded synchronously tuned circuits, for several offset frequencies. The separation between adjacent filters is 100 cps.